Soil CO_2, CH_4 and N_2O effluxes and concentrations in soil profiles down to 15.5m depth in eucalypt plantations under contrasted rainfall regimes

Details

Meeting	2017 Fall Meeting
Section	Global Environmental Change
Session	Advances in Monitoring and Reporting Greenhouse Gas Emissions and Sinks Across Land Use Categories II Posters
Identifier	GC21B-0941
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Index Terms	Biogeochemical cycles, processes, and modeling [0414] Carbon cycling [0428] Ecosystems, structure and dynamics [0439] Land cover change [1632]

Abstract

Silvicultural practices in planted forests affect the fluxes of greenhouse gases at the soil surface and the major factors driving greenhouse gas production in forest soils (substrate supply, temperature, water content,) vary with soil depth. Our study aimed to assess the consequences of drought on the temporal variability of CO2, CH4 and N2O fluxes throughout very deep soil profiles in Eucalyptus grandis plantations 3 months before the harvest then in coppice, the first 18 months after clear-cutting. Two treatments were compared: one with 37% of throughfall excluded by plastic sheets (TE), and one without rainfall exclusion (WE). Measurements of soil CO2 efflux were made every two weeks for 30 months using a closed-path Li8100 system in both treatment. Every two weeks for 21 months, CO2, CH4 and N2O surface effluxes were measured using the closed-chamber method and concentrations in the soil were measured at 7 depths down to 15.5 m in both TE and WE. At most measurement dates, soil CO2 efflux were significantly higher in TE than in WE. Across the two treatments and the measurement dates, CO2 concentrations increased from 4446 2188 ppm at 10 cm deep to 15622 3523 ppm at 15.5 m, CH4 concentrations increased from 0.41 0.17 ppm at 10 cm deep to 0.77 0.24 ppm at 15.5 m and N2O concentrations remained roughly constant and were on average 478 55 ppb between soil surface and 15.5 m deep. CO2 and N2O concentrations were on average 20.7 and 7.6% lower in TE than in WE, respectively, across the sampling depths. However, CH4 concentrations in TE were on average 44.4% higher than in WE, throughout the soil profile. Those results suggest that extended drought periods might reduce the production of CO2 and N2O but increase the accumulation of CH4 in eucalypt plantations established in deep tropical soils. Very deep tropical soils cover huge areas worldwide and improving our understanding of the spatiotemporal dynamics of gas concentrations in deep soil layers is essential to: i) quantify more accurately C source/sink fluxes as part of the global carbon budget, ii) improve the current biogeochemical models predicting the effect of drought periods on greenhouse gas effluxes, and iii) identify more sustainable silvicultural practices for tropical planted forests in a context of climate change.

Cite as: Author(s) (2017), Title, Abstract GC21B-0941 presented at 2017 Fall Meeting, AGU, New Orleans, Louisiana, 11-15 Dec.